



US010194566B2

(12) **United States Patent**  
**Johansson**

(10) **Patent No.:** **US 10,194,566 B2**

(45) **Date of Patent:** **Jan. 29, 2019**

(54) **FEED-THROUGH**

(71) Applicant: **HANS-ERIK JOHANSSON I**  
**HAGSTAD AKTIEBOLAG**, Gnosjö  
(SE)

(72) Inventor: **Hans-Erik Johansson**, Gnosjö (SE)

(73) Assignee: **HANS-ERIK JOHANSSON I**  
**HAGSTAD AKTIEBOLAG** (SE)

(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **15/529,469**

(22) PCT Filed: **Dec. 17, 2015**

(86) PCT No.: **PCT/EP2015/080208**

§ 371 (c)(1),

(2) Date: **May 24, 2017**

(87) PCT Pub. No.: **WO2016/097137**

PCT Pub. Date: **Jun. 23, 2016**

(65) **Prior Publication Data**

US 2017/0303446 A1 Oct. 19, 2017

(30) **Foreign Application Priority Data**

Dec. 19, 2014 (SE) ..... 1451594

Jan. 20, 2015 (SE) ..... 1550044

(51) **Int. Cl.**

**H05K 9/00** (2006.01)

(52) **U.S. Cl.**

CPC ..... **H05K 9/0018** (2013.01); **H05K 9/0098**  
(2013.01); **H05K 9/0007** (2013.01); **H05K**  
**9/0049** (2013.01); **H05K 9/0081** (2013.01)

(58) **Field of Classification Search**

CPC ..... H05K 9/0018

See application file for complete search history.

(56) **References Cited**

**U.S. PATENT DOCUMENTS**

3,830,954 A 8/1974 Caudill  
4,148,543 A 4/1979 Shores  
4,677,253 A 6/1987 Blomqvist  
4,733,016 A \* 3/1988 Twist ..... F16L 5/08  
174/657

(Continued)

**FOREIGN PATENT DOCUMENTS**

DE 37 11 937 C1 7/1988  
DE 40 13 886 A1 10/1991

(Continued)

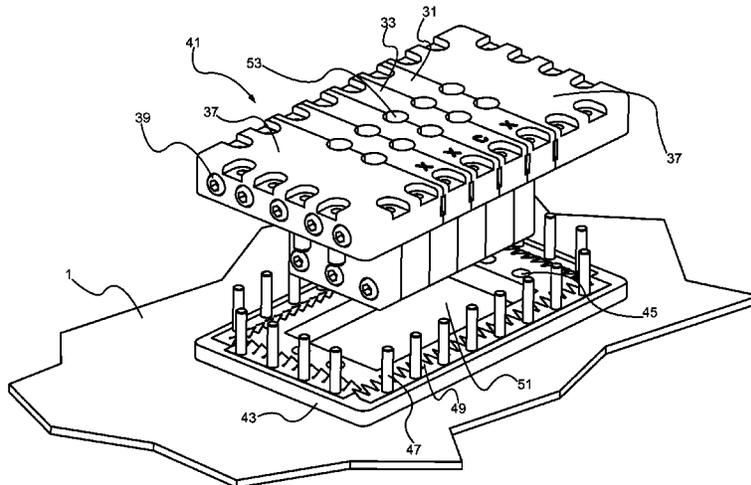
*Primary Examiner* — Hung V Ngo

(74) *Attorney, Agent, or Firm* — Condo Roccia Koptiw  
LLP

(57) **ABSTRACT**

A feed-through provides electromagnetic shielding where one or more signal leads pass through an enclosure. It comprises a frame, having at least one opening, and an assembly comprising two or more joining parts, forming one or more elongated waveguides. The joining parts are divisible along the length of the waveguides, thereby being capable of surrounding a signal lead. The assembly is adapted to be attached to the frame such that one or more signal leads can pass through an opening in the frame and through one of the waveguides. Installation is of the feed-through is made easier by the opening in the frame having a larger maximum extension than the maximum extension of a waveguide.

**24 Claims, 12 Drawing Sheets**



(56)

**References Cited**

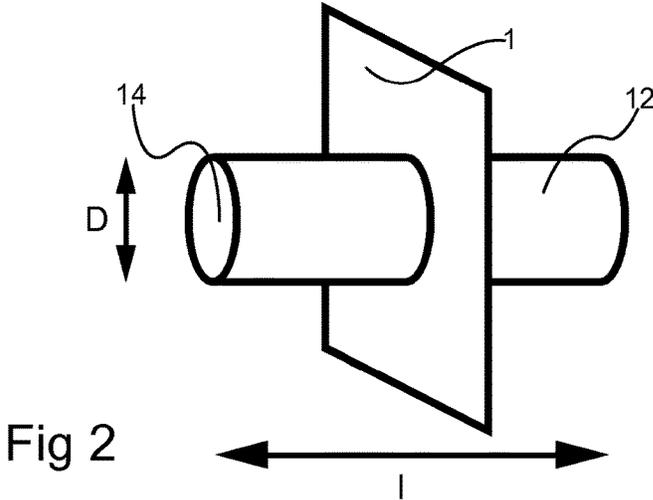
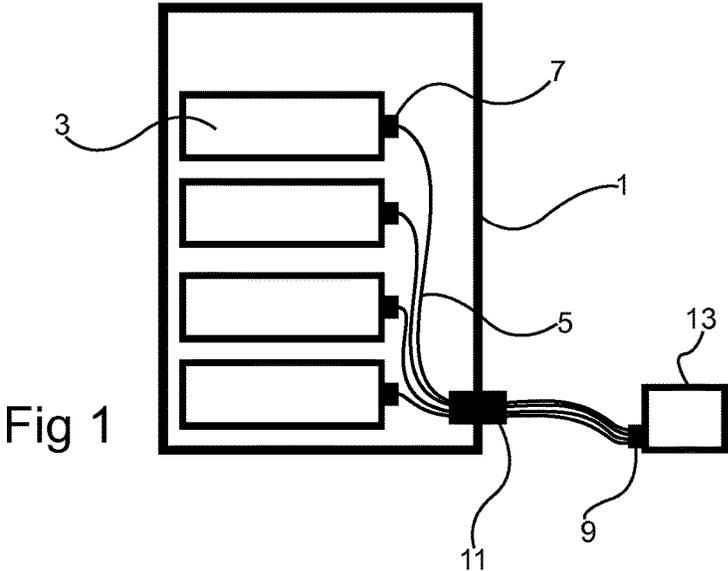
U.S. PATENT DOCUMENTS

4,849,723 A 7/1989 Oliver, Jr.  
5,416,271 A \* 5/1995 Birmingham ..... F16L 5/08  
174/657  
5,938,152 A \* 8/1999 Kreutz ..... F16L 5/08  
174/656  
6,262,370 B1 7/2001 Kreutz  
6,713,672 B1 3/2004 Stickney  
7,793,415 B2 9/2010 Vitt et al.  
8,674,240 B2 \* 3/2014 Karlsson ..... F16L 5/08  
174/652  
2003/0042032 A1 \* 3/2003 Syed ..... H02G 3/0481  
174/36  
2007/0209832 A1 \* 9/2007 Ball ..... H05K 9/0067  
174/370  
2009/0194644 A1 8/2009 Lundborg  
2009/0257198 A1 \* 10/2009 Rogers ..... H05K 5/023  
361/726  
2010/0001476 A1 \* 1/2010 Broder ..... F16L 5/08  
277/606  
2010/0154325 A1 \* 6/2010 Boesel ..... H05K 9/0018  
52/173.1

FOREIGN PATENT DOCUMENTS

EP 0 293 042 A1 11/1988  
FR 2 611 333 B1 8/1988  
SE 441 795 B 11/1985  
SE 508 755 C2 11/1998  
SE 528 689 C2 1/2007  
WO WO 99/34537 7/1999  
WO WO 99/45619 A1 9/1999

\* cited by examiner



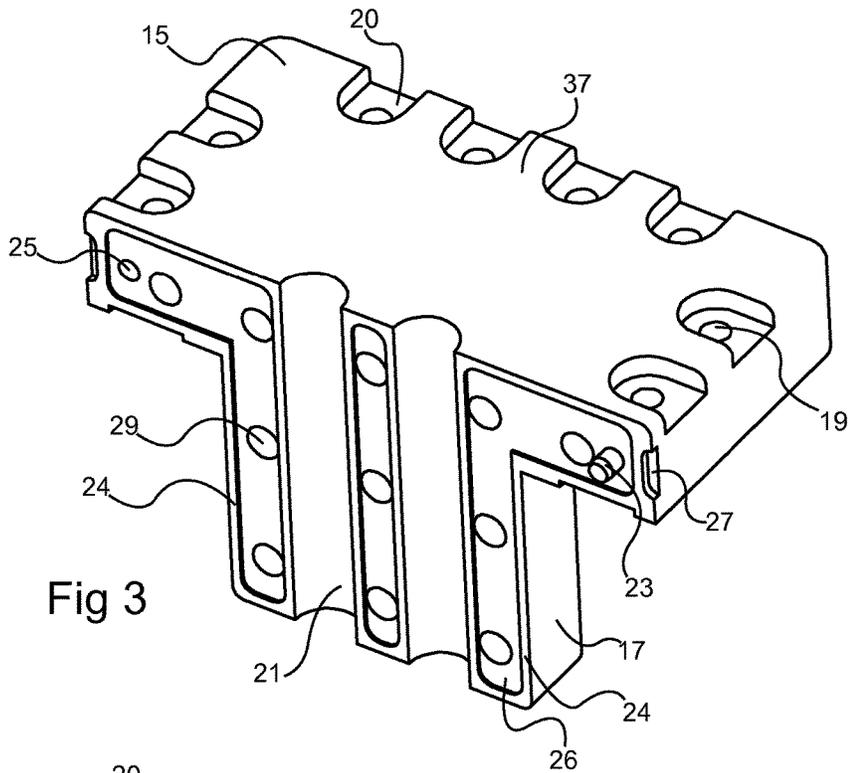


Fig 3

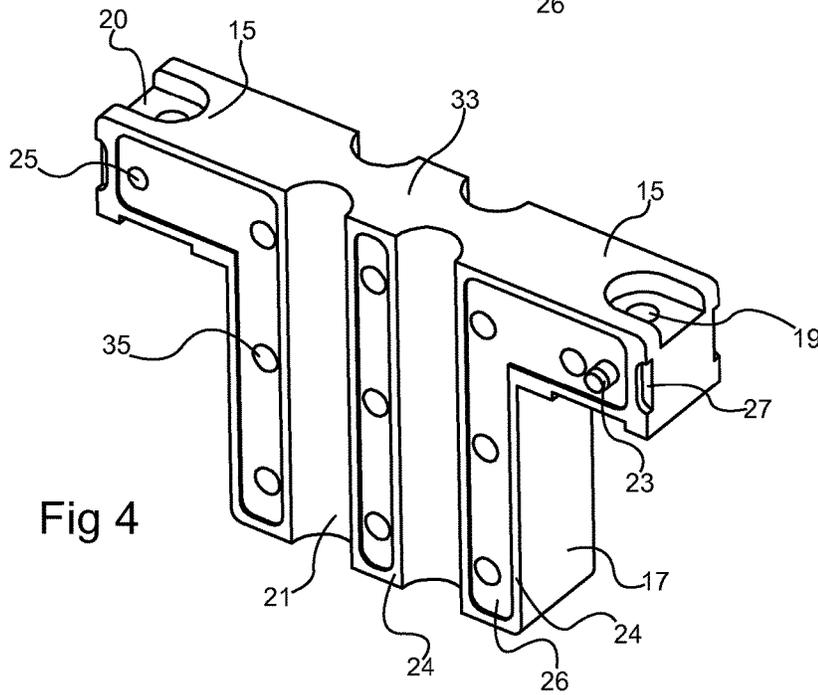


Fig 4

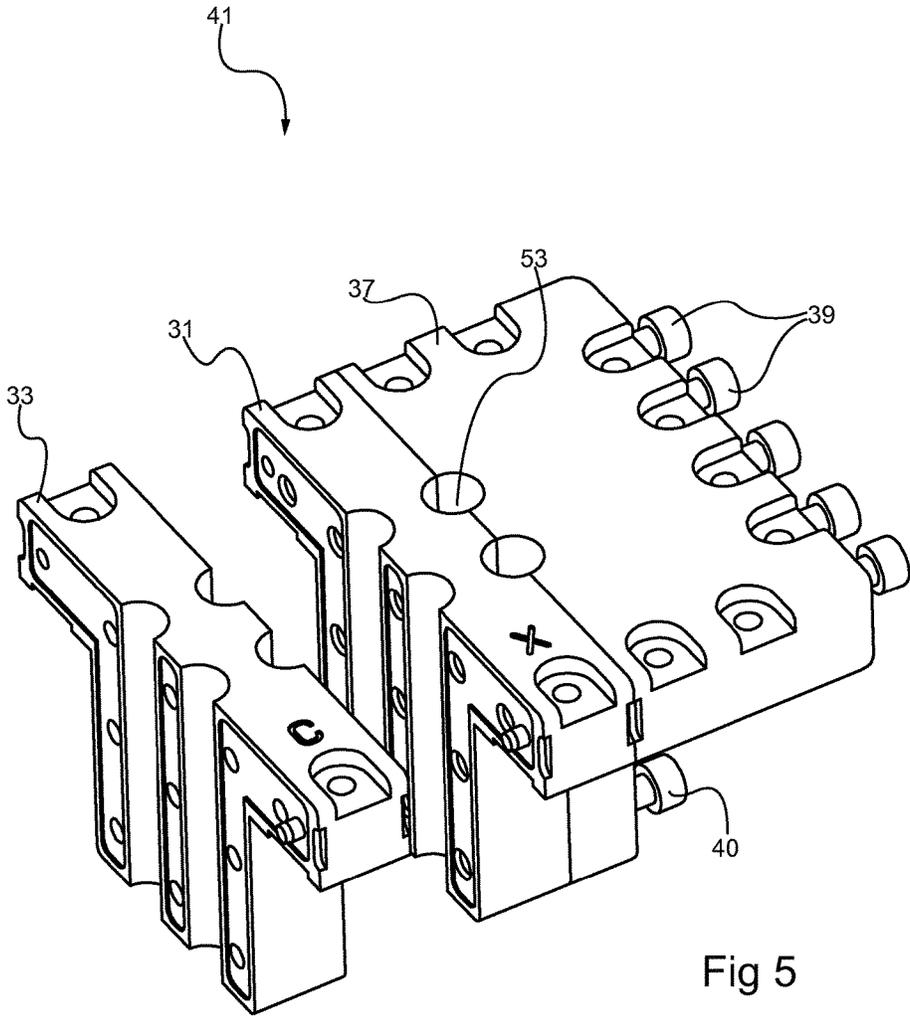


Fig 5

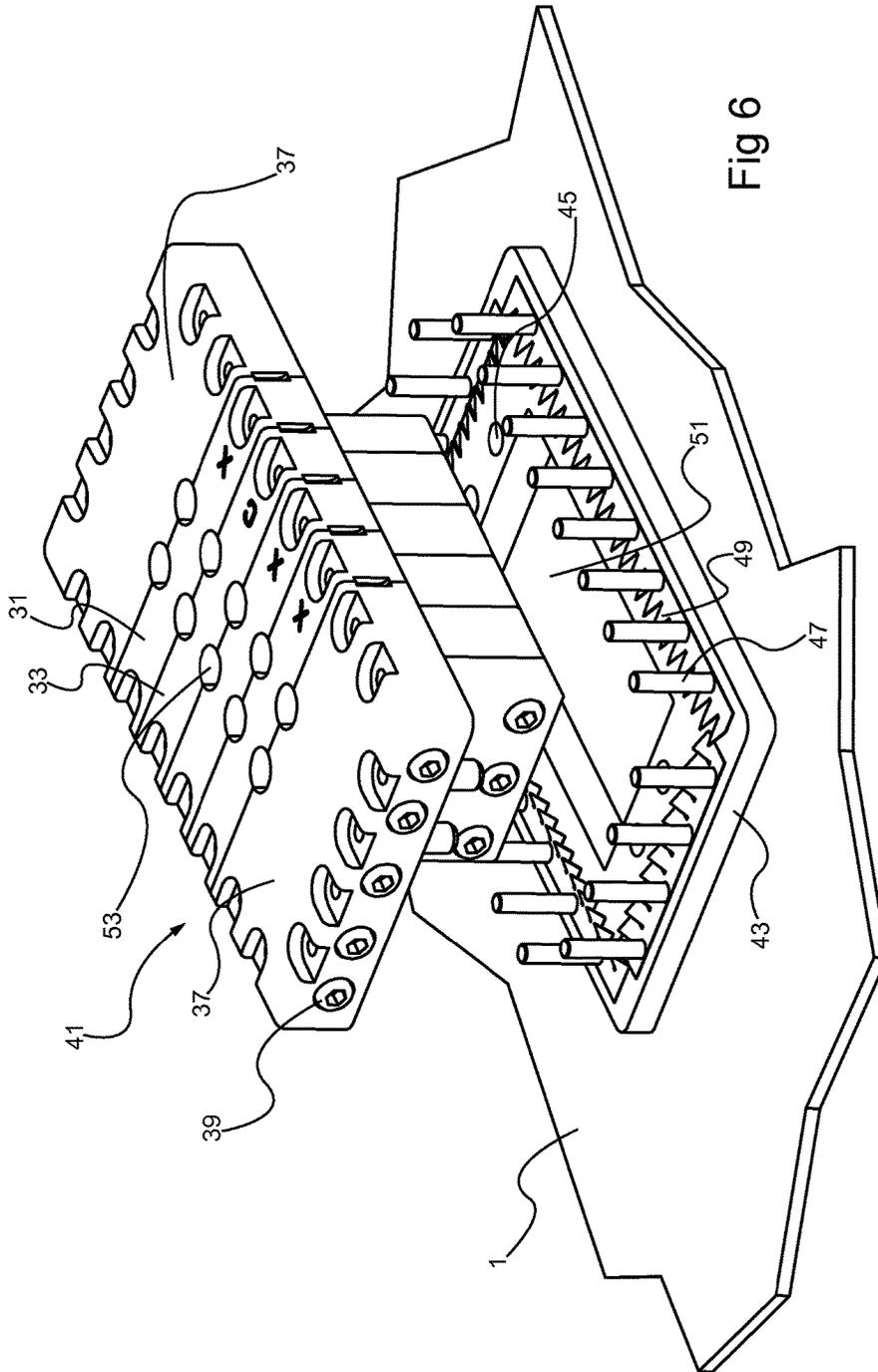
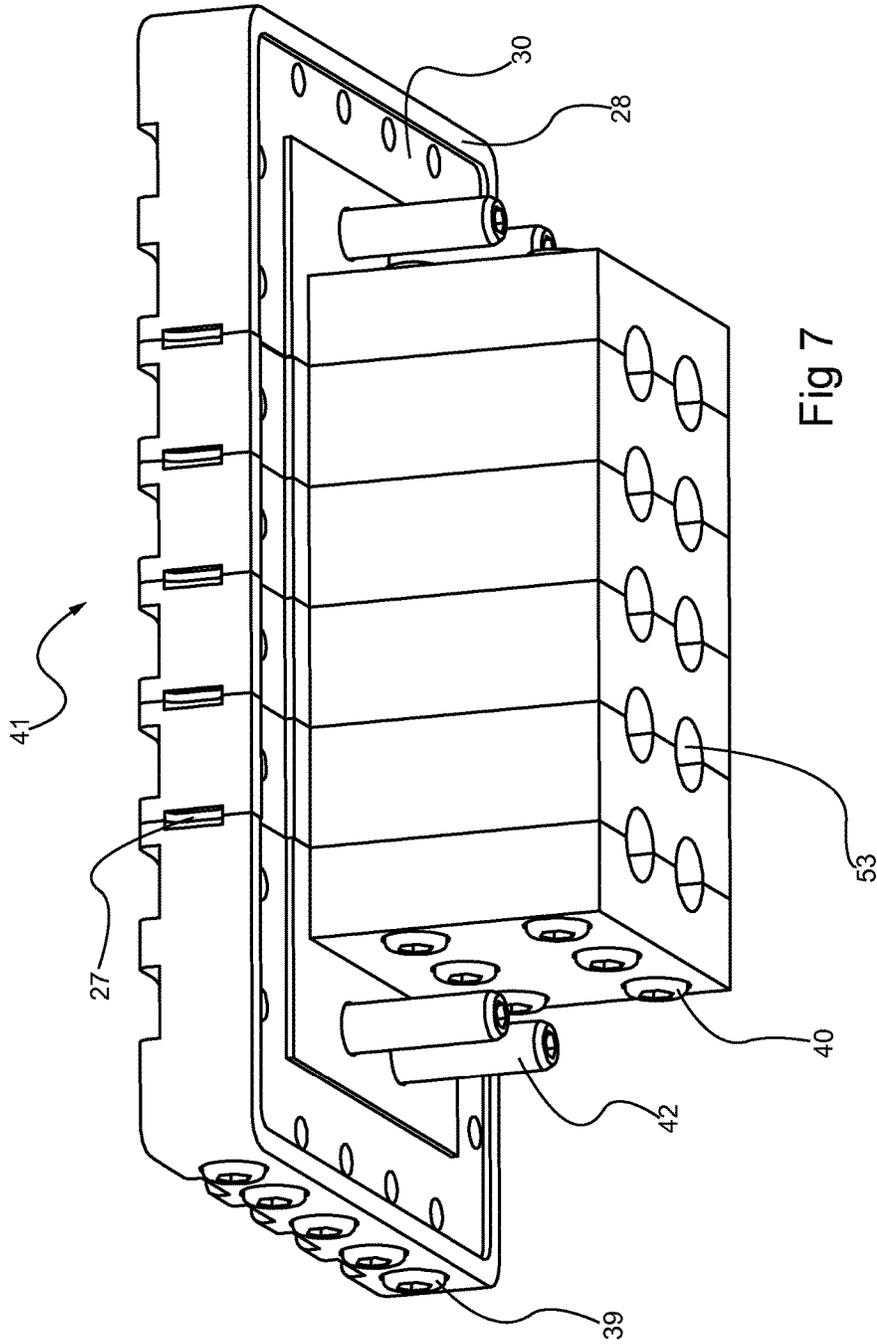


Fig 6



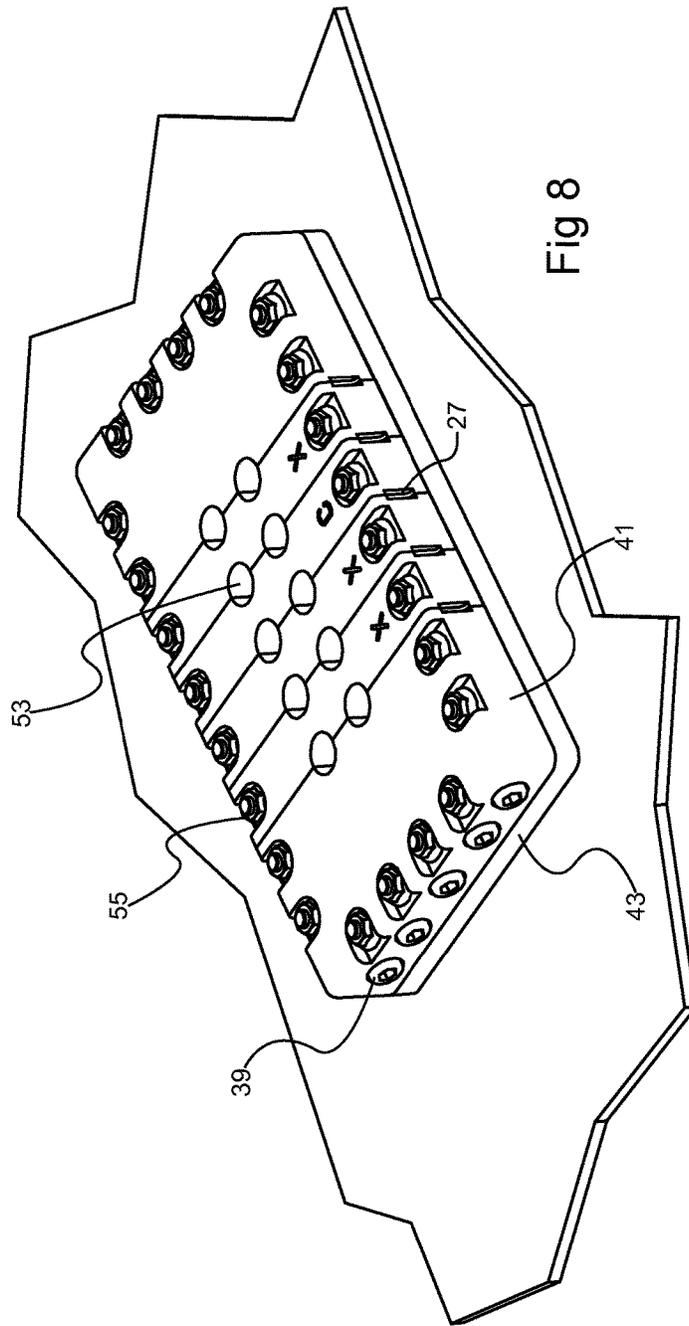


Fig 8

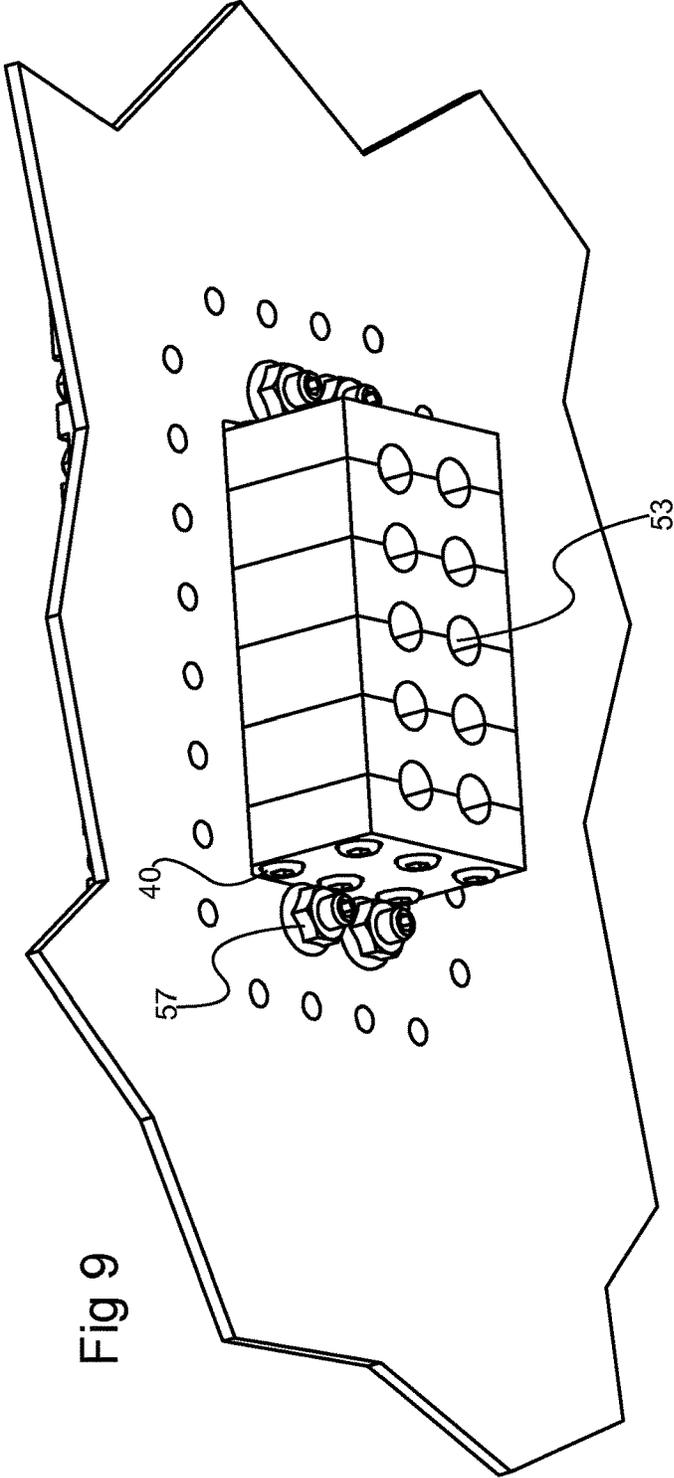


Fig 9

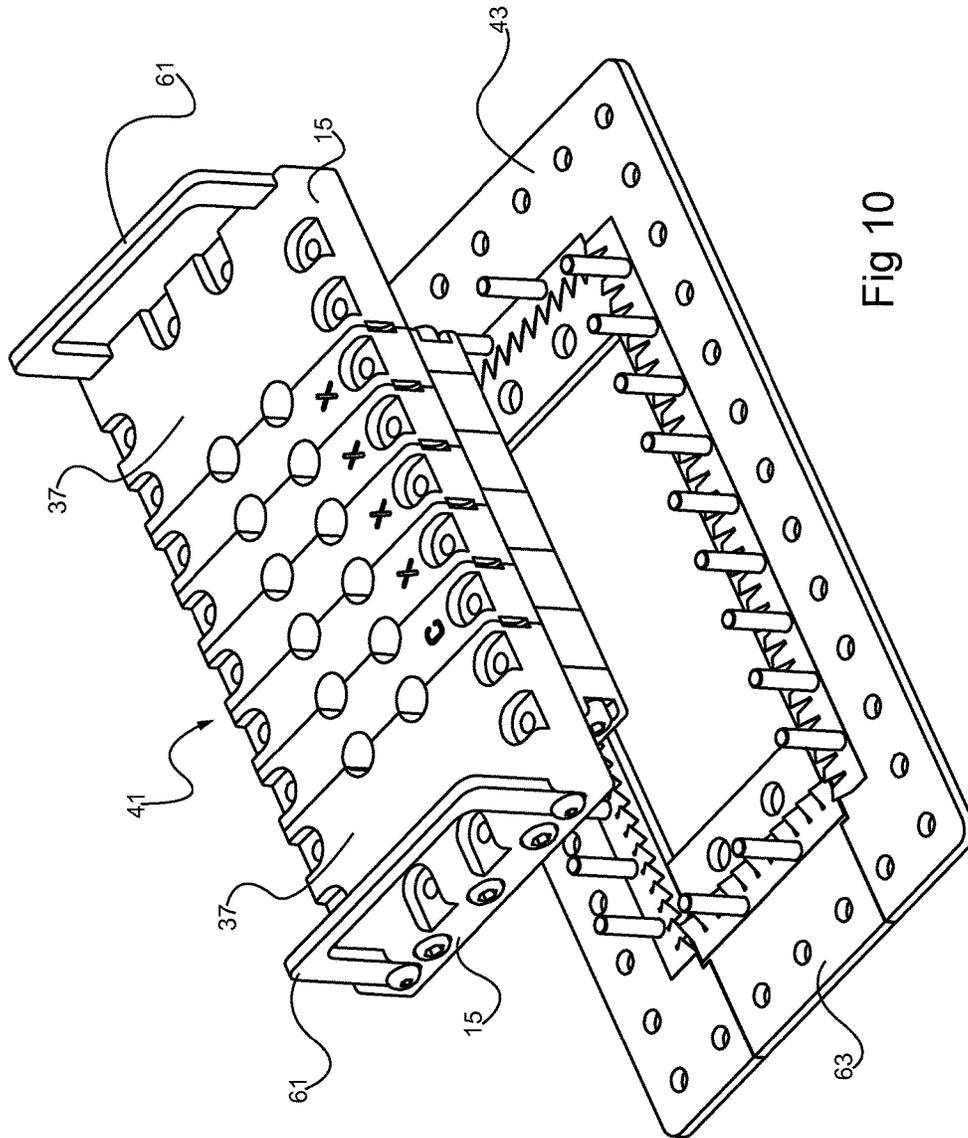


Fig 10



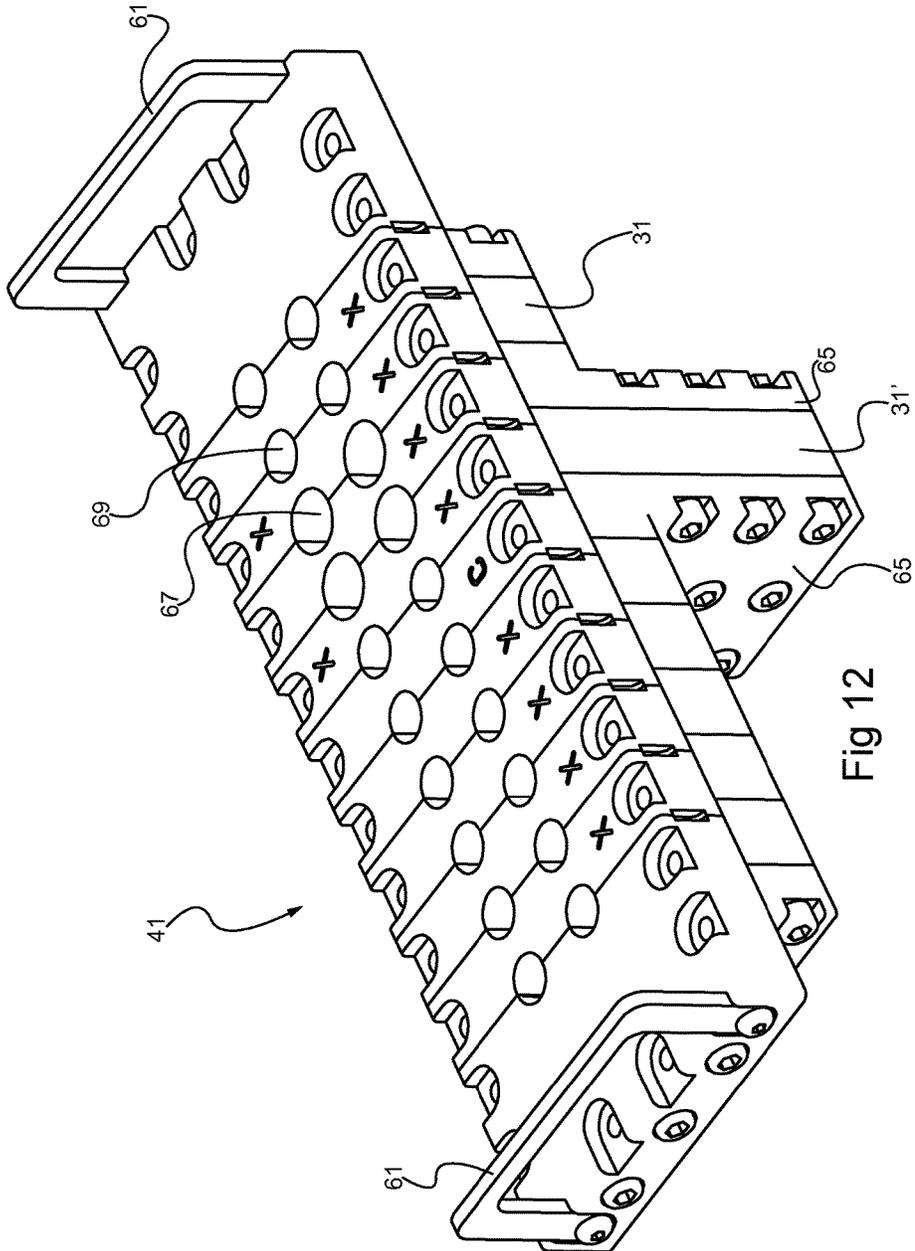


Fig 12

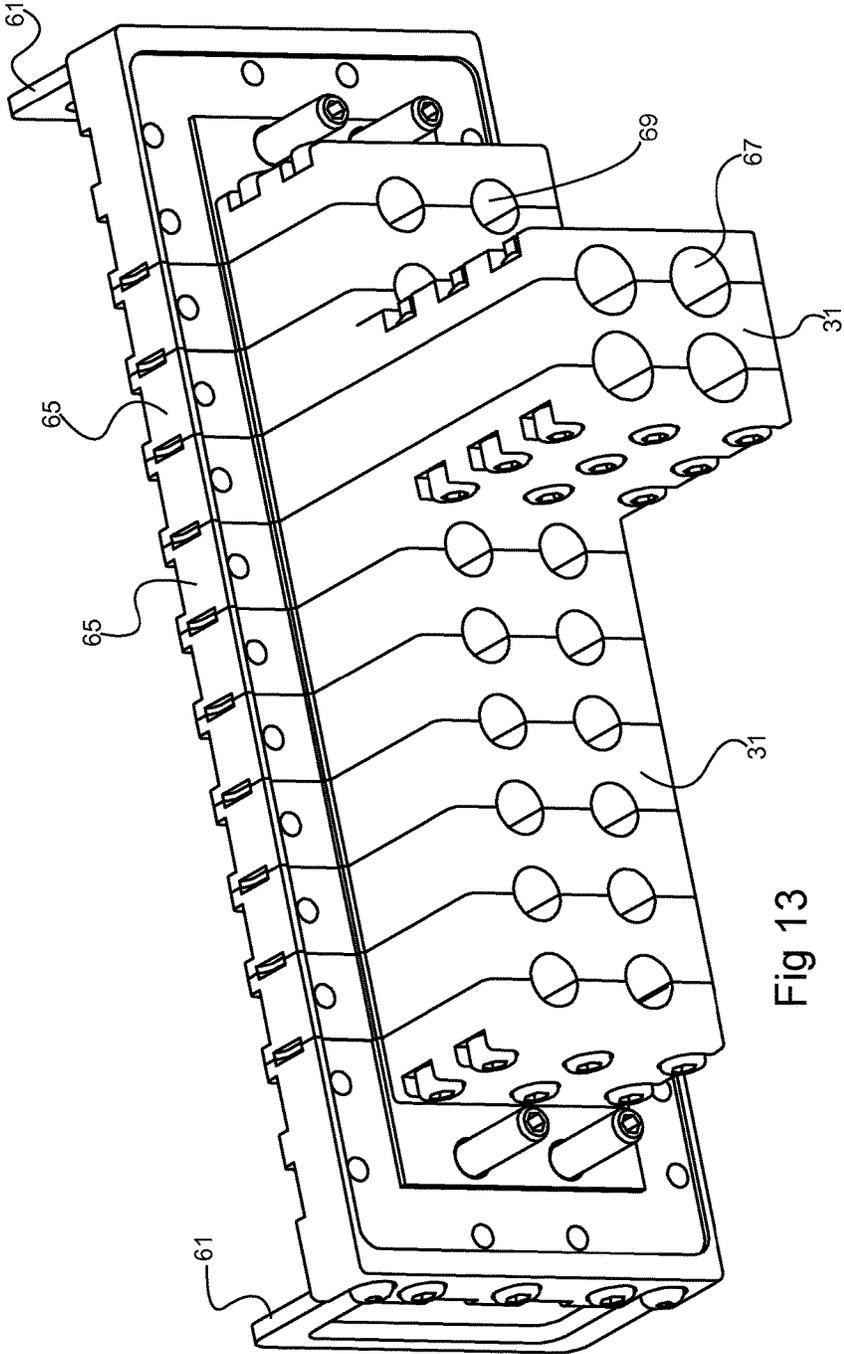


Fig 13

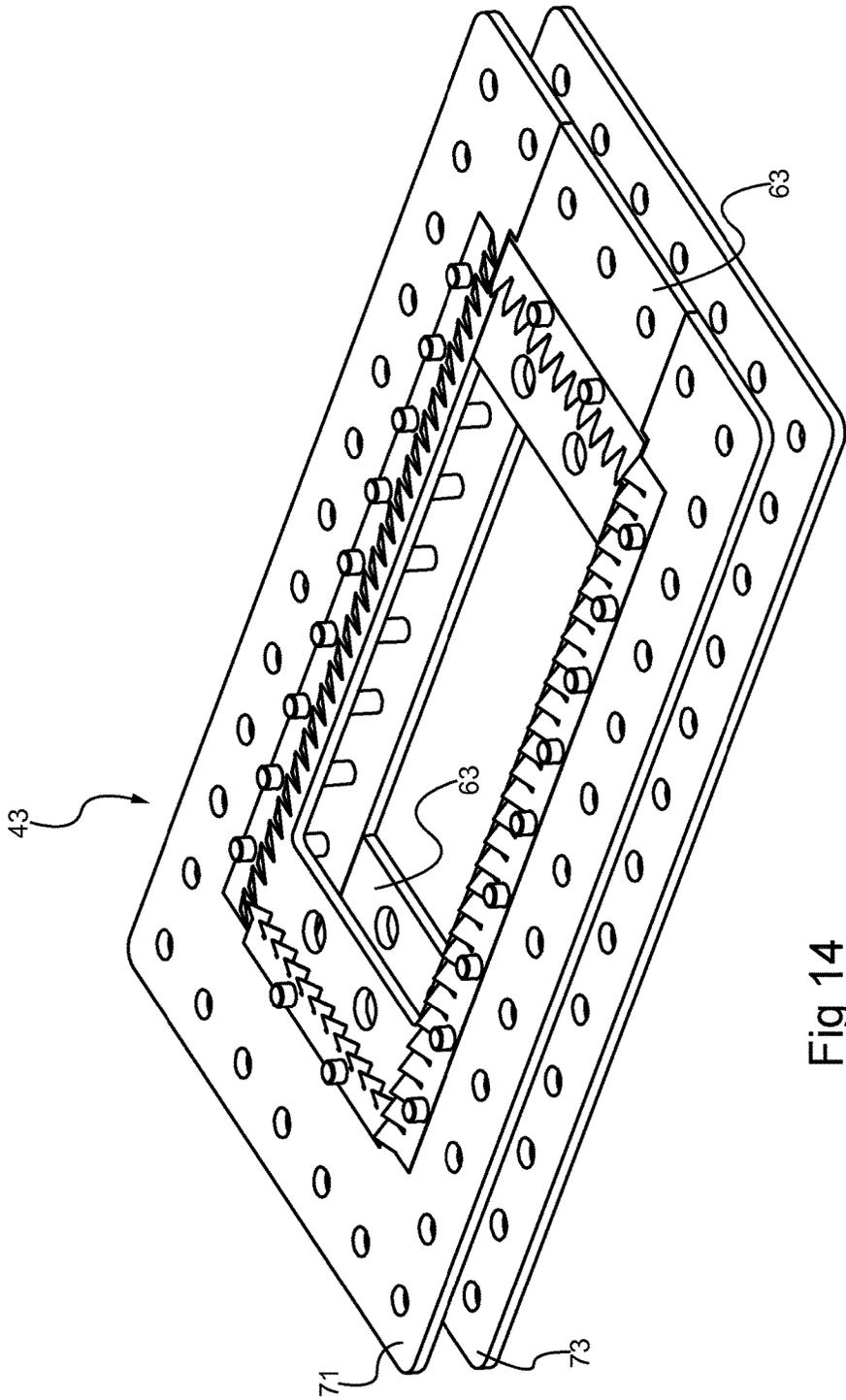


Fig 14

1

**FEED-THROUGH****CROSS REFERENCE TO RELATED APPLICATIONS**

This application is the National Stage Entry under 35 U.S.C. § 371 of Patent Cooperation Treaty Application No. PCT/EP2015/080208, filed 17 Dec. 2015, which claims the benefit of Sweden Application No. 1550044-0, filed 20 Jan. 2015, and Sweden Application No. 1451594-4, filed 19 Dec. 2014, the disclosures of which are incorporated herein by reference in their entireties.

**TECHNICAL FIELD**

The present invention relates to a feed-through for providing electromagnetic shielding where one or more signal leads pass through a cabinet or other enclosure.

**BACKGROUND**

Such a feed-through can be used to prevent emission of electromagnetic waves, for example to avoid electromagnetic interference or the leakage of critical information from a network switch or server placed in a cabinet or enclosure. For the latter application, standards, usually referred to using the term “TEMPEST”, are established that require attenuation up to the order of 100 dB at frequencies up to 10 GHz at the feed-through.

One example of such a feed-through, for optical cables, is described in U.S. Pat. No. 7,793,415-B2, which shows a flat member with a number of openings. An enclosure can be fitted around each cable to form a tube, and this tube can be attached to the flat member at an opening thereof. The flat member is in turn attached to an opening of a cabinet or other enclosure. This structure reduces electromagnetic interference to a desired level up to a frequency that is determined by the length and the inner diameter of the tube formed by the enclosure.

One problem associated with such a feed-through is how to facilitate installation of, for example, optical cables in a cabinet or other enclosure where the feed-through is used.

**SUMMARY**

One object of the present invention is therefore how to facilitate installation of, for example, optical cables in cabinets or other enclosures where the feed-through is used.

This object is achieved by means of a feed-through as defined in claim 1. More specifically, such a feed through comprises a frame, having at least one opening, and at least one assembly comprising two or more joining parts, forming one or more elongated waveguides. The joining parts are divisible along the length of the waveguides, thereby being capable of surrounding a signal lead. The assembly is adapted to be attached to the frame such that one or more signal leads can pass through an opening in the frame and through one of the waveguides. Further, the opening in the frame then has a larger maximum extension than the maximum cross section extension of a waveguide.

With such a feed-through it is possible, while providing a reasonably short waveguide with a small diameter, to install, for example, a pre-terminated fiber-optic cable, i.e., one that has already been provided with a connector, which has a considerably greater cross section than a fiber-optic cable. The frame may be attached to a cabinet or other enclosure, and the user may stick the fiber-optic cable, or a bundle of

2

cables, with a connector at its end, through the opening in the frame, which opening is large enough to allow this. The joining parts are then fitted around the cable or cables such that the cables run in an elongated cavity in the interior of the finished assembly. This can be achieved even in cases where the cavity is narrower than the connector. Means for attaching the parts together are provided. The enclosing parts are then firmly connected to the frame. Thereby pre-terminated cables can be used, which makes any installation procedure considerably more efficient.

The number of cables that need to be fed through a cabinet wall may vary greatly between different applications. One way to achieve flexibility in the number of cables possible to be fed through is to let the assembly consist of a variable number of parts, with a variable number of optional middle parts between two end parts. Installation is facilitated by the completed assembly forming one solid block without extending and/or fragile parts.

Machined parts allowing high precision may be used, making a tight fit between the parts possible, thus preventing the leakage of electromagnetic radiation between the parts. The frame may be welded to the cabinet to prevent leakage of radiation between the frame and the cabinet. A frame with a thickness larger than 10 mm may be used in order to facilitate welding. An electrically conductive gasket, such as a copper-beryllium gasket, can be used to prevent leakage of electromagnetic radiation between the assembly and the frame. The parts in the assembly may be made from steel, which has good conductive properties, resulting in a well-functioning waveguide. Tying the parts together using nuts and bolts is one way to assure tight electric contact between them.

In general, the longer a waveguide is, the larger the attenuation will be. In addition, for a waveguide to be able to attenuate a given frequency, that frequency needs to be below the cut-off frequency of the waveguide. Standards as discussed above mandate a certain minimum attenuation, leading to waveguides needing to have a certain minimum length and maximum transversal extension. In this case, the waveguides may have length of at least 52 mm and/or a maximal transversal extension of at most 17.5 mm.

On the connecting surfaces between joining parts, there may be recesses, the use of which may result in good electric and mechanical contact between the parts.

Space is often tight in and around cabinets of the mentioned kind. Allowing the waveguides to extend through the opening in the cabinet is one way of saving space. In particular, more space is often available outside of the cabinet. A configuration wherein the feed-through extends further on the outside than on the inside of the cabinet will make better use of available space.

Handles may be placed on any of the parts of the assembly to aid installation and removal. To aid installation, the frame may comprise one or more detachable parts. Furthermore, the frame may be comprised of two or more layers that may attach to each of the walls of a cabinet having several walls.

Different waveguides may be of different lengths according to need, for example to save space and material. The signal lead going through the feed-through is typically a fiber-optic cable.

The object mentioned in the first paragraph may also be achieved by means of a system, comprising the mentioned feed-through, a cabinet or enclosure, and one or more signal leads.

**BRIEF DESCRIPTION OF THE DRAWINGS**

These and other aspects of the invention will now be described in more detail, with reference to embodiments of the invention.

FIG. 1 schematically illustrates a situation where a feed-through according to the present disclosure can be used.

FIG. 2 schematically illustrates a waveguide below-cut-off.

FIG. 3 is a perspective drawing of an end part of an assembly.

FIG. 4 is a perspective drawing of a middle part of the assembly.

FIG. 5 is a perspective drawing showing how the parts of the assembly fit together.

FIG. 6 is a perspective drawing showing a view of a completed assembly and how the assembly is attached to the frame.

FIG. 7 is a perspective drawing showing another view of a completed assembly.

FIG. 8 is a perspective drawing showing one side of an installed feed-through.

FIG. 9 is a perspective drawing showing another side of an installed feed-through.

FIG. 10 is a perspective drawing showing an embodiment of the invention in which the assembly has handles and the frame has a detachable part.

FIG. 11 is a perspective drawing showing an embodiment of the invention in which several assemblies are mounted on one frame and each assembly has handles.

FIG. 12 is a perspective drawing showing one side of an assembly in an embodiment of the invention where the waveguides have different lengths.

FIG. 13 is a perspective drawing showing another side of an assembly in an embodiment of the invention where the waveguides have different lengths.

FIG. 14 is a perspective drawing showing a frame in an embodiment of the invention in which the frame has two layers.

### DETAILED DESCRIPTION

FIG. 1 illustrates a protected cabinet or other enclosure 1, which is a context where a feed-through 11 according to the present disclosure can be used. Such a cabinet or other enclosure can be used in a sensitive environment where processing devices 3 in the cabinet 1, such as servers, electronically process unencrypted sensitive information. The cabinet 1, which may be made of thick sheet metal, functions as a Faraday cage, containing within its enclosure any electromagnetic radiation from the processing devices 3, thereby preventing the leakage of sensitive information. The processing devices 3 communicate with nodes 13 outside the cabinet 1 via optical fibers 5 which are terminated by means of connectors 7, 9 at each end. The optical fibers may convey less sensitive information or the information carried by them may be encrypted. Furthermore, the conveyed optical signals as such usually give negligible leaked radiation, preventing interception of such signals, unless the fibers are tampered with.

The feed-through where the optical fibers extend out of the cabinet 1 requires special attention so that electromagnetic radiation does not escape the cabinet, risking interception by a third party nearby.

In addition to the shielding situation described above, the feed-through may be useful in other situations where considerable attenuation at a connection into a Faraday cage is needed. For instance, as the effect provided is more or less reciprocal, the feed-trough could protect sensitive equipment in a cabinet from external electromagnetic interference, such as electromagnetic pulses with high energy.

Further, a shielded room used for sensitive measurements could be protected from external electromagnetic interference, etc.

As is well known per se, an attenuating feed-through can be obtained by means of a waveguide below-cutoff, WBCO, of which one example is schematically illustrated in FIG. 2. In this example the waveguide 12, made from a conductive material, has a cavity 14, open at both ends, with a circular cross section with diameter D and a length l. The waveguide extends through a wall in a Faraday cage 1.

Electromagnetic waves can propagate through a waveguide in a number of different modes, corresponding to different solutions to the Maxwell equations. These modes are distinguished by different configurations of the electric and magnetic fields. Each of these modes has a cut-off frequency, below which no substantial propagation in that mode is possible. Below the lowest cut-off frequency of all possible modes, no substantial propagation of electromagnetic waves is possible at all. Instead, signals suffer exponential attenuation. In a circular waveguide, the mode with the lowest cut-off frequency is the TE<sub>11</sub> (transverse electric) mode. The cut-off frequency  $f_c$  of that mode can be shown to be, to three significant figures,

$$f_c = \frac{0.586 v}{D},$$

where v is the propagation speed of the waveguide dielectric, i.e., the nonconductive material forming the bulk of the waveguide cavity. In air, v is to a good approximation  $3 \times 10^8$  m/s. Below this cut-off frequency, over a distance l, an electromagnetic wave with frequency f suffers a total attenuation of, again to three significant figures,

$$A = 32.0 \frac{l}{D} \sqrt{1 - \left(\frac{f}{f_c}\right)^2} \text{ dB.}$$

It can thus easily be realized that to maximize attenuation of signals of a certain frequency requires as high a cut-off frequency as possible, and thus as narrow a waveguide as possible, as well as a long a waveguide as possible. It can also be seen that the larger the diameter a waveguide has, the longer the waveguide needs to be to achieve target attenuation.

For a feed-through to function properly according to the strictest current standards, i.e. a dampening of 100 dB between frequencies 10 kHz and 10 GHz, the cross-section diameter of a waveguide should preferably be smaller than about 17.5 mm. With an example cross-section diameter of 12 mm, a waveguide should preferably be longer than about 52 mm.

FIG. 6 shows the parts of a complete feed-through. The feed-through comprises a frame 43 and an assembly 41, the latter comprising two end parts 37 and between them, optionally, one or more middle parts 31, 33. FIG. 5 shows how the parts of the assembly fit together. As the parts comprising the assembly are brought together, waveguides 53 are formed from cut-outs on those parts. A minimal configuration of the assembly 41 could consist of only two end parts 37. Any number of middle parts 31, 33 can then be placed between them according to need. Middle parts 31, 33 can be made slightly different, e.g. with 33 or without 31 threads. Middle parts with threads 33 are on the drawings

marked "C", while those without threads **31** are marked "X". This arrangement allows a tight fit between the parts. At the same time, the finished assembly is rugged without any extending fragile parts and not likely to break apart during installation. The completed assembly **41** as shown in FIG. **6** fits into an opening **51** of the frame **43**.

In the embodiment described here, the parts of the assembly are made from steel, which material has good electric conducting properties, allowing for a well-functioning waveguide. Machined parts are used, which allows high precision, allowing for a tight fit between the parts. However, the skilled person realizes that other fabrication methods and other materials with good electrical conductivity are also possible.

An electrically conducting gasket, such as a copper-beryllium gasket **49** may be used to prevent leakage of electromagnetic radiation between the assembly **41** and the frame **43**. Copper-beryllium gaskets are rugged and easy to use.

A person skilled in the art realizes that other arrangements, such as an arrangement of conductive gaskets made from, for example, silicone or rubber mixtures, lying flat on the frame **43** or running in one or more grooves in the frame, are conceivable as well.

FIGS. **3** and **4** show different parts making up the assembly **41** (cf. FIG. **6**); an end part **37**, and one example of a middle part **33**. As mentioned above, there may be provided middle parts with holes **35** having threads, and middle parts **31** (cf. FIG. **5**) with corresponding holes not having threads.

An end part **37** comprises a flange portion **15** and a protruding section **17** perpendicular to the flange. A middle part **31**, **33** comprises two flange portions **15** and one protruding section **17**.

The flanges **15** are devised to be attached to the frame **43** (cf. FIG. **6**). On each middle part **31**, **33**, one flange portion **15** is located on each side of the protruding portion. On the flanges **15**, there are holes **19** in a direction perpendicular to the flanges **15**, extending through the flanges. These holes **19** are suitable for attaching the assembly **41** to the frame **43**. In the particular embodiment of the disclosure described here, middle parts **31**, **33** have one such hole **19** on each flange, while an end part **37** has four holes **19** on the edge of the flange facing away from the protruding section **17** and two holes **19** on each of the two edges perpendicular to the edge facing away from the protruding section **17**. At the entrance to each hole **19**, there may be a recess **20** suitable for giving space for a nut.

On the protruding section **17** on both end parts **37** and middle parts **31**, **33**, there are connecting surfaces **24** that will be in contact as the parts of the assembly are brought together. On the middle parts **31**, **33** there are such surfaces on each side of the protruding section **17** and flanges, while on end parts **37**, there are such surfaces only on a side of the protruding section **17** facing away from the flange **15**. The peripheries of these surfaces may be raised, such that there is provided recesses **26** there between, where holes **29**, **35** for bolts are provided, in order to improve mechanical/galvanic contact between the surfaces of different parts by permitting higher pressure at the contact surfaces **24**. In the embodiment described here, such raised edges are present on the middle parts **31**, **33**, as well as on the end parts **37**.

At the connecting surfaces described above, there are cut-outs **21** that, when matched with corresponding middle **31**, **33** or end parts **37**, form the waveguides. In the embodiment described here, there are two such cut-outs at each connecting surface. The cut-outs extend along the whole length of the parts **31**, **33**, **37**.

In the embodiment described here, the cut-outs are semi-circular. However, a person skilled in the art realizes that cut-outs of other shapes, such as quadratic, rectangular, honeycomb or general polygon shaped are equally possible. A person skilled in the art would additionally recognize that it is equally possible to have a different number of cut-outs than two on the surfaces of the parts and to have cutouts that for one waveguide have different cut-outs on the two different parts forming that waveguide.

Additionally, on the connecting surfaces described above, there may be pins **23** and holes **25** to aid alignment of end parts **37** and/or middle parts **31**, **33** attaching to each other. In the embodiment described here, those pins **23** and holes **25** are located on the flanges **15**, near the end of the connecting surfaces. Just outside of the pins **23** and holes **25**, on the edge between the flange **15** and the connecting surface, there may be smaller cut-outs **27**, designed to aid disassembly, if desired, for example by inserting a screwdriver into the cut-out **27** and turning the screwdriver and/or using it as a lever.

In the recesses at the connecting surfaces described above, there are through holes **29** extending perpendicularly to the surfaces, in the protruding sections **17** and the flanges **15**. In the embodiment described here, on the middle parts **31**, **33**, there is one such hole **29** through each of the flanges **15**. On end parts **37**, there is one such hole **29** though each side of the flange **15**. On both end **27** and middle **31**, **33** parts, there are three rows of holes **29** extending though the protruding section **17**. One such row is located on one side of the two cut-outs **21**, one row on the other side of the cut-outs **21** and one row between the cut-outs **21**. The number of holes **29** in each row depends on the length of the protruding section **17**. In the embodiment described here, each row has three holes **29**. Needless to say, the hole configurations may be varied in a number of ways.

On middle parts **31**, **33**, the holes described in the previous paragraph may be threaded **33** or be without threads **31**.

FIG. **5** shows how the assembly **41** is fitted together, here exemplified with an end part **37**, a middle part **31** without threads, and a middle part **33** with threads being attached to each other using bolts **39**, **40**. The bolts may interact with the threads **35** (cf. FIG. **4**) of middle parts **33** having such threads or with nuts if the bolts penetrate the entire assembly. Thereby the parts are compressed, bringing the connecting surfaces described above into close contact. The skilled person will recognize that other means for applying this pressure than bolts and optional nuts are possible.

As already has been discussed, FIG. **6** shows a completed assembly **41**, the frame **43**, and a wall of the cabinet **1**. The frame **43** can have a rectangular cross section and an opening **51**, also rectangular in cross-section, where the narrower part of the assembly **41** fits, i.e., the part of the assembly comprised of the protruding sections **17** of the parts **31**, **33**, **37** making up the assembly. The frame may for example have been welded to the cabinet, although other ways of fitting the frame to the wall are conceivable. To be suitable for welding to the cabinet **1**, it may be beneficial for the frame **43** to have a thickness in a direction perpendicular to the plane of one side of the cabinet of at least 10 mm.

In the embodiment described here, the waveguides **53** formed by the joining parts **31**, **33**, **37** are at a right angle to the plane of the frame **43** or of one side of the cabinet **1**. However, it is equally possible for the waveguides **53** and the protruding sections **17** of the joining parts **31**, **33**, **37** to be at an oblique angle to the flanges **15**, resulting in a feed-through with signal leads **5** entering the cabinet **1** at an oblique angle with respect to the plane of the frame **43** or of

one side of the cabinet **1**. This may have an advantage of saving space inside the cabinet.

When the assembly has been put together, with leads in the waveguides, the assembly is fitted in the frame and firmly attached to the frame.

Threaded bolts **47** attached to the frame **43** match holes in the flanges **15** of the parts comprising the assembly **41**. These bolts may for example have been press fitted into the frame. A set of holes **45**, in the embodiment described two holes along each short side of the opening **51** in the frame **43**, extend through the frame **43** and through the cabinet **1**.

FIG. **7** shows another side of a completed assembly **41**. Bolts **39**, **40** attaching the parts together are present both through the flanges and through the protruding parts. Another set of bolts **42**, hidden in FIG. **3**, in the embodiment described two bolts **42** on each side, are attached to the end parts on the flange **15** close to the protruding section **17**. These bolts **42** match the holes **45** in the frame described above. Attaching the assembly with bolts from both sides of the cabinet **1** makes the feed-through more tamper-resistant and make unauthorized access to the cabinet though the feed-through more difficult.

The assembly **41** as illustrated has contact surfaces **28** beneath the flanges. These contact surfaces **28** are devised to come into close contact with corresponding surfaces on the frame **43**, optionally with an intervening gasket **49**. These contact surfaces as well may have recessed portions **30** as well, in order to leave space for a gasket **49**.

FIG. **8** shows one side of a complete feed-through, with the completed assembly **41** attached to the frame **43**. Nuts **55** may attach to the bolts **47** attached to the frame **43**.

FIG. **9** shows the other side of a complete feed-through. Nuts **57** may attach to the bolts **42** attached to the end parts.

FIG. **10** shows an embodiment of the invention in which the assembly **41** has handles **61** and the frame **43** has a detachable part **63**. In this embodiment, the handles are mounted at each end of the assembly **41**, on the edges of the flanges **15** of the end parts of the assembly **41**. The handles are mounted using screws, and facilitate the handling of the assembly. Other locations of the handles and ways of mounting them are equally possible.

The detachable part **63** of the frame **43** is located by one short edge of the frame and may aid installation of the feed-through. For instance it is possible to fit the frame around a pre-installed set of cables, and thereafter close the frame with the separate, detachable part. The frame is then attached to the enclosure wall. It is also possible to use a fame structure on both sides of a wall. The detachable part **63** may thus be a cut-out from the frame, for instance with stepped shape to reduce any electromagnetic leaks.

FIG. **11** shows an embodiment of the invention in which several assemblies **41**, in this case three, are mounted on one frame **43**. Each assembly **41** has handles **61**. The handles **61** are mounted on the assemblies **41** in the same way as in the embodiment depicted in FIG. **10**. Each assembly **41** is mounted in its own opening of the frame. Removable parts **63** of the frame **43** are located adjacent to a short edge of each assembly **43** and may aid installation of the feed-through.

FIG. **12** shows an embodiment of the invention in which the waveguides have varying lengths. Varying the length of the waveguides in the same assembly **41** may save space and material. As described above, a waveguide with a larger diameter **67** will need to be longer to achieve a given attenuation than a waveguide with a smaller diameter **69**. At the same time, the space for a signal lead given by a large-diameter waveguide may not be needed for all wave-

guides in a feed-through. Shown is an assembly **41** with middle parts **31** that form shorter waveguides and middle parts **31'** that form longer waveguides. Between middle parts of the two mentioned types, there are transitional parts **65**, to which further bolts and nuts can be attached to firmly fasten the parts forming longer waveguides together along the whole length of the waveguides. As in the embodiments depicted in FIG. **10** and FIG. **11**, the assembly **41** has handles **61**. FIG. **13** shows another side of the same embodiment.

FIG. **14** is a perspective drawing showing a frame **43** in an embodiment of the invention in which the frame has two layers **71**, **73**. Each layer **71**, **73** of the frame **43** has a detachable part **63**, which may aid installation of the feed-through. In a cabinet having double walls each layer of the frame may be attached to each of the walls. It is also possible to two stacked layers on one side of a single wall, or on either side of a single wall. As the detachable parts are located on opposite sides in the two layers, any electromagnetic leaks can be reduced. Needless to say, more than two layers can be provided.

The present disclosure is not limited by the above example, and may be varied and altered in different way within the scope of the appended claims.

The invention claimed is:

**1.** A feed-through for providing electromagnetic shielding, comprising:

a frame that comprises an opening; and

an assembly comprising two or more joining parts configured to form one or more elongated waveguides, the joining parts being made of a conductive metal, divisible along a length of the one or more elongated waveguides and capable of surrounding one or more signal leads, wherein the joining parts are configured to be attached to each other, wherein the assembly is configured to be attached to the frame via one or more flanges to allow the one or more signal leads to pass through the opening in the frame and through one of the one or more elongated waveguides, and wherein the opening in the frame has a larger maximum transversal extension than the maximum transversal extension of the one or more elongated waveguides.

**2.** The feed-through according to claim **1**, wherein the joining parts are configured to form two or more elongated waveguides, the opening in the frame providing access to more than one of the two or more elongated waveguides to allow the one or more signal leads to pass through the opening in the frame and through any of the two or more elongated waveguides.

**3.** The feed-through according to claim **1**, wherein the one or more elongated waveguides have a length of at least 52 mm.

**4.** The feed-through according to claim **1**, wherein the one or more elongated waveguides have a maximal transversal extension of at most 17.5 mm.

**5.** The feed-through according to claim **1**, wherein a connecting surface between the two or more joining parts comprises a recess.

**6.** The feed-through according to claim **1**, wherein the one or more elongated waveguides are configured to extend through the opening in the frame.

**7.** The feed-through according to claim **6**, wherein the feed-through is configured to provide electromagnetic shielding when the one or more signal leads pass through a cabinet, the one or more elongated waveguides being configured to extend further on the outside of the cabinet than on the inside of the cabinet.

8. The feed-through according to claim 7, wherein the frame has a thickness of at least 10 mm perpendicular to the plane of one side of the cabinet.

9. The feed-through according to claim 7, wherein the frame is suitable for welding to the cabinet.

10. The feed-through according to claim 1, wherein the frame and the assembly are made from machined parts.

11. The feed-through according to claim 1, wherein the frame and the assembly are made of steel.

12. The feed-through according to claim 1, further comprising an electric contact between the frame and the assembly, the electric contact being secured by a gasket made from a conductive material.

13. The feed-through according to claim 12, wherein the conductive material comprises beryllium-copper.

14. The feed-through according to claim 1, wherein the feed-through is configured to provide electromagnetic shielding when the one or more signal leads pass through a cabinet, and wherein the one or more signal leads comprise a fiber-optic cable.

15. The feed-through according to claim 1, wherein the two or more joining parts and/or the assembly are configured to be connected to the frame via one or more bolts.

16. The feed-through according to claim 15, wherein the two or more joining parts and/or the assembly are further configured to be connected to the frame via one or more nuts.

17. The feed-through according to claim 1, wherein the assembly further comprises a handle.

18. The feed-through according to claim 1, wherein the frame comprises one or more detachable parts.

19. The feed-through according to claim 1, wherein the frame comprises two or more layers.

20. The feed-through according to claim 1, wherein the one or more elongated waveguides have different lengths.

21. The feed-through according to claim 1, wherein the frame comprises two or more openings.

22. The feed-through according to claim 1, wherein the feed-through is configured to provide electromagnetic shielding when the one or more signal leads pass through a cabinet, and wherein the frame comprises a rectangular cross section in a plane of the cabinet when the frame is attached to the cabinet, the opening in the frame being rectangular in

cross section in the plane of the cabinet, the two or more joining parts of the assembly comprising two end parts and one or more middle parts between the two end parts, each of the two end parts comprising a flange fitting to two edges along a first major axis of the frame, each of the two end parts further comprising a protruding section at a right angle to the flange, the protruding section of each of the two end parts comprising a first set of one or more cut-outs, the one or more middle parts comprising two flanges fitting to two edges along a second major axis of the frame, the one or more middle parts further comprising a protruding section at a right angle to the two flanges, the protruding section of the middle parts comprising a second set of one or more cut-outs on both sides that face other joining parts, the first and second sets of cutouts forming the one or more elongated waveguides.

23. The feed-through according to claim 22, wherein the one or more middle parts are of two types, one type including a hole with threads fitting a bolt that is used to connect the joining parts and/or the assembly to the frame, the other type including a hole without threads.

24. A system, comprising:  
a feed-through, the feed-through comprising:  
a frame that comprises an opening; and  
an assembly comprising two or more joining parts configured to form one or more elongated waveguides, the joining parts being made of a conductive metal, divisible along a length of the one or more elongated waveguides and capable of surrounding one or more signal leads, wherein the joining parts are configured to be attached to each other, wherein the assembly is configured to be attached to the frame via one or more flanges to allow the one or more signal leads to pass through the opening in the frame and through one of the one or more elongated waveguides, and wherein the opening in the frame has a larger maximum transversal extension than the maximum transversal extension of the one or more waveguides;  
an enclosure suitable for electromagnetic shielding; and  
one or more signal leads.

\* \* \* \* \*